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(54) Title: METHODS AND SYSTEMS FOR SWITCHING TERMINALS FROM PACKET SWITCHED SERVICE TO CIRCUIT SWITCHED SERVICE

(57) Abstract: Systems and methods for suspending packet switched communications in a user terminal that is configured to operate in both a circuit switched network and a packet switched network. The packet switched network is notified via an interface between the packet switched network and the circuit switched network to suspend communications to a user terminal. This may be accomplished by notifying a gateway node in the circuit switched network that the user terminal is no longer registered in the packet switched network, and by then relaying this information from the gateway node to a control node of the packet switched network via the interface between the networks. The suspend message may be sent in response to the circuit switch network receiving a call origination message from the user terminal, or, alternatively, in response to the circuit switch network receiving an incoming call to the user terminal. In this latter situation, the user terminal may be notified of the incoming call via a page, which the user terminal then responds to via a page response that is sent to the circuit switched network.

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METHODS AND SYSTEMS FOR SWITCHING TERMINALS FROM PACKET SWITCHED SERVICE TO CIRCUIT SWITCHED SERVICE

FIELD OF THE INVENTION

The present invention relates to radiotelephones, and, more particularly, to methods and systems for switching radiotelephones between different services.

BACKGROUND OF THE INVENTION

As is well known to those of skill in the art, a communications network is a collection of resources which interconnects and provides for communications between various computers, telephones, and other network users that are located at geographically separate locations. Cellular telephone networks comprise one such type of communications network, where a plurality of mobile users communicate with each other and/or with other users on a traditional telephone network via geographically dispersed base stations or "cells" which provide network access to the mobile users located within their coverage region.

Early cellular telephones were generally analog devices that were dedicated largely to voice communication circuits. These cellular telephones typically operated in "circuit switched" networks, meaning that in response to a call request, the network established a private transmission path (or "channel") which was held for the duration of the call. Accordingly, other users were not allowed access to the resources comprising the transmission path until after the entire communication has been completed.

In recent years, a proliferation of digital cellular telephones have been developed that, in addition to supporting standard voice communications, also support

a wide variety of data communications services such as faxes, file transfers between computers, electronic mail, paging and the like. For many of these non-voice communications, it may be more efficient to communicate over the network using "packet switched" as opposed to "circuit switched" communications. In packet switched networks, blocks of data (data packets) are transferred from one network user to another network user using a transmission path allocated by the network. However, all the data packets which comprise a communication need not always use the same transmission path. Moreover, as a particular transmission path in the network is not reserved for any particular communication, many network users may share some or all of the segments comprising a particular transmission path during the course of their respective communications.

In light of the above, cellular telephones have been developed which support both circuit switched and packet switched communications. Users of these telephones can simultaneously register with both a circuit switched and a packet switched network. Typically, if the cellular telephone is "idle" (*i.e.*, it is not engaged in a circuit switched call), it will "camp" on the packet switched network. While camping on the packet switched network, the cellular telephone can transmit and receive packet switched data communications. When the cellular telephone user decides to originate a circuit switched call, or when another network user places a circuit switched call to the cellular telephone, the cellular telephone suspends its packet switched communications and accesses the circuit switched network to complete the circuit switched call.

ClassB136 Mobile Station refers to a cellular telephone under the IS-136 network protocol that is configured to operate in both a circuit switched network and a packet switched network. With ClassB136 Mobile stations, the circuit switched communications are carried over an ANSI 41 circuit switched network and the packet switched communications are carried over a General Packet Radio Service ("GPRS") packet switched network. Under current protocols for ClassB136 Mobile, when a circuit switched call request is received for a cellular telephone that is camped on the packet switched network, the ANSI 41 network pages (*i.e.*, sends a message to) the cellular telephone via a communications link or "interface" that is provided between

the ANSI 41 network and the GPRS packet switched network. Upon receiving the page, the cellular telephone sends a suspend message to a GPRS control node that notifies the GPRS packet switched network that the cellular telephone is no longer available for packet switched communications. Pursuant to existing specifications, this message is sent using a contention based access mode on an uplink channel of the packet switched network.

Once the suspend message is received and acknowledged, the cellular telephone accesses the Digital Control Channel ("DCCH") of the ANSI 41 circuit switched network, and sends a response to the page to a control node in that network (the Serving Mobile Switching Center or "Serving MSC"). Thereafter, one or more control nodes in the ANSI 41 network operate to connect the circuit switched call.

Ideally, cellular telephone users will experience little or no delay in connecting calls. However, in current ClassB136 Mobile networks a noticeable delay may be present when switching a cellular telephone that is camped on a packet switched network to the circuit switched network. Accordingly, there is a need for improved methods and systems for switching dual service cellular telephones from packet switched to circuit switched service.

SUMMARY OF THE INVENTION

In view of the above, it is an object of the present invention to provide systems and methods which may reduce the time required to switch a user terminal in packet data service mode to circuit switched mode.

Another object of the present invention is to provide systems and methods which reduce the number of control messages transmitted from user terminals to control nodes via capacity limited cellular transmission links.

These and other objects of the present invention are provided by systems and methods for switching a user terminal that is configured to operate in both a circuit switched network and a packet switched network from packet switched service to circuit switched service. Pursuant to these methods and systems, in response to receiving a call connection message from a user terminal, the circuit switched network determines, based on the registration status of the user terminal, if the user

terminal is accessing the circuit switched network after leaving the packet switched network. If so, the user terminal sends a suspend message to the packet switched network via an interface between the packet switched network and the circuit switched network that notifies the packet switched network to suspend all communications to the user terminal. The suspend methods and systems described herein may be faster than prior art techniques for switching from packet switched service to circuit switched service, and thus may decrease the time required for a user terminal to place or receive a circuit switched call. Additionally, the systems and methods of the present invention may advantageously reduce the number of control messages which are sent via wireless transmission links between the user terminals and the packet switched network.

In a specific embodiment of the present invention, a method of requesting suspension of packet switched communications to a user terminal that is configured to operate in both a circuit switched network and a packet switched network is provided. Pursuant to this method, the circuit switched network, responsive to receiving a call connection message from the user terminal, determines, based on a registration status of the user terminal, if the user terminal has switched from the packet switched network to the circuit switched network. If so, the circuit switched network sends a suspend message to the packet switched network via an interface between the circuit switched network. This suspend message may be sent prior to establishing a call connection for the user terminal.

In a preferred embodiment of this method, the circuit switched network is an ANSI 41 network having a Serving MSC and a Gateway MSC and the packet switched network is a GPRS network having a SGSN node. In this embodiment, the Serving MSC receives the call connection message from the user terminal, the suspend message is sent by the Gateway MSC to the SGSN node via an interface between the ANSI 41 network and the GPRS network, and the step of determining if the user terminal has switched from the packet switched network to the circuit switched network step is performed at the Gateway MSC in response to receiving notification that the user terminal has accessed the ANSI 41 network. In preferred embodiments of the invention, this notification may be provided to the MSC by

sending an unsolicited response message from the Serving MSC to the Gateway MSC or by sending a registration cancellation message to the Gateway MSC.

Pursuant to an alternative embodiment of the present invention, methods of switching a user terminal that is configured to operate in both an ANSI 41 circuit switched network having a Serving MSC and a Gateway MSC and a GPRS packet switched network having a SGSN node from GPRS communications to ANSI 41 communications are provided. According to these methods, the user terminal accesses a control channel in the ANSI 41 network, on which it may send a message to the Serving MSC. In response to this message, the Gateway MSC may be notified that the user terminal has accessed the ANSI 41 network. A suspend message may then be sent from the Gateway MSC to the GPRS network via an interface between the GPRS network and the ANSI 41 network. Thereafter, the GPRS network may suspend packet switched communications to the user terminal, and an ANSI 41 communications channel may be allocated to the user terminal.

The methods of the present invention may advantageously be employed in GPRS-136HS mobile systems, in which the user terminals are mobile cellular user terminals that operate in both a GPRS packet switched network having a Serving GPRS Support Node ("SGSN") switch node and an ANSI 41 circuit switched network having a Serving MSC and a Gateway MSC. In such instances, the packet switched network and the circuit switched network may be connected via a Gs interface. Additionally, corresponding systems for carrying out these methods are also provided.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram illustrating a user terminal that is simultaneously registered in both a packet switched network and in a circuit switched network;

Figure 2 is a flow chart depicting a method of suspending packet switched communications to a user terminal according to the present invention;

Figure 3 is a flow chart depicting a method of switching a dual mode user terminal from a packet switched GPRS network to circuit switched ANSI 41 network

according to the present invention, wherein in the ANSI 41 network the Serving MSC also acts as the Gateway MSC;

Figure 4 is a flow chart depicting a method of switching a dual mode user terminal from a packet switched GPRS network to circuit switched ANSI 41 network according to the present invention, wherein in the ANSI 41 network the Serving MSC is separate from the Gateway MSC;

Figure 5 is a flow chart depicting a prior art method by which a user places a call to a mobile user in a circuit switched network;

Figure 6 is a schematic diagram depicting various of the communications which may be used to switch a dual mode user terminal from a packet switched GPRS network to circuit switched ANSI 41 network according to an embodiment of the present invention, where the switch is being made in response to an incoming call and the Gateway MSC also acts as the Serving MSC;

Figure 7 is a schematic diagram depicting various of the communications which may be used to switch a dual mode user terminal from a packet switched GPRS network to circuit switched ANSI 41 network according to an embodiment of the present invention, where the switch is being made in response to an incoming call and the Gateway MSC is separate from the Serving MSC;

Figure 8 is a schematic diagram depicting various of the communications which may be used to switch a dual mode user terminal from a packet switched GPRS network to circuit switched ANSI 41 network according to an embodiment of the present invention, where the switch is being made in response to the user terminal deciding to originate a circuit switched call, and the Gateway MSC also acts as the Serving MSC; and

Figure 9 is a schematic diagram depicting various of the communications which may be used to switch a dual mode user terminal from a packet switched GPRS network to circuit switched ANSI 41 network according to an embodiment of the present invention, where the switch is being made in response to the user terminal deciding to originate a circuit switched call, and the Gateway MSC is separate from the Serving MSC.

DETAILED DESCRIPTION OF THE INVENTION

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Additionally, it will be understood by those of skill in the art that the present invention may be advantageously used in a variety of applications, and thus the present invention should not be construed as limited in any way to the example applications described herein. Like numbers refer to like elements throughout.

Figure 1 depicts a communications system in which the methods and systems of the present invention may be used. The communications system of **Figure 1** includes a user terminal **10** that operates in two different networks **20, 30**. A "user terminal" may refer to any communications device, such as a telephone, computer, fax machine, etc.,; however, in a preferred embodiment of the present invention the user terminal 10 is a mobile cellular telephone user. As shown in **Figure 1**, the first of these networks is a packet switched network **20**, which, in the example of **Figure 1**, is a GPRS network. This packet switched network **20** includes one or more control nodes **22**, which, in the case of a GPRS network, typically are SGSN nodes. The packet switched network **20** also includes a number of base stations **23, 25, 27**, which are the nodes through which user terminals such as a user terminal **10** may access the packet switched network **20**. These base stations **23, 25, 27** are typically connected to one or more control nodes **22**. Note that in **Figure 1** the connections between base stations, control nodes and other network devices in the same network "cloud" are not shown (to simplify the drawing), as these connections will be apparent to one skill in the art in light of the present disclosure and standard network connectivity concepts.

When multiple SGSN nodes **22** are employed, each SGSN node **22** will typically be responsible for a specific geographic portion of the packet switched network (*i.e.*, the base stations **23, 25, 27** will be divided between the SGSN nodes **22**). Control communications between the packet switched network **20** and the user

terminal **10** may be logically transmitted over a control link **24**, which in the case of a GPRS network would, typically, comprise a Packet Control Channel ("PCCH") or a Packet Data Channel ("PDCH"). While the PCCH and PDCH are physical links between a base station **23, 25, 27** and a user terminal **10**, the link is shown in **Figure 1** as going directly from the user terminal **10** to the SGSN node **22** since the base station **23, 25, 27** forwards the information carried over these channels **24** to and from the SGSN **22**, and thus a "logical" connection exists directly between the SGSN **22** and the user terminal **10**.

As is also shown in **Figure 1**, packet switched data communications between the user terminal **10** and the packet switched network **20** are carried over communications channels **26**. The GPRS network may further include an Home Location Register ("HLR") **28**, which serves as a centralized database for the packet switched network. Information regarding various network users, such as the user terminal **10**, is stored in the HLR **28** and can be accessed by the SGSNs **22**.

As illustrated in **Figure 1**, the user terminal **10** may also operate in a circuit switched network **30**. In the example of **Figure 1**, the circuit switched network **30** is an ANSI 41 circuit switched network having one or more Serving MSCs **32** and one or more Gateway MSCs **34**. In an ANSI 41 circuit switched network such as the network depicted in **Figure 1**, a plurality of base stations **33, 35, 37** are typically associated with each Serving MSC **32**. In the illustrative network of **Figure 1**, only a single Serving MSC **32** is provided, and as such, all three base stations **33, 35, 37** depicted in **Figure 1** would typically be associated with the depicted Serving MSC **32**. As with the GPRS packet switched network **20**, the base stations **33, 35, 37** of the ANSI 41 network **30** also typically serve as the network access point for user terminals such as the user terminal **10**.

The Serving MSC **32** assigned to a base station **33, 35, 37** typically is responsible for performing various control functions associated with the user terminals **10, 12** which are accessing the base stations **33, 35, 37** assigned to that Serving MSC **32** (these user terminals **10, 12** are "registered" in the network **30** with that Serving MSC **32**). A broadcast signal is typically transmitted by each base station **33, 35, 37** that allows a user terminal **10, 12** to know which base station **33, 35,**

37 to access. When a user terminal **10, 12** exits the area of a base station **33, 35, 37** assigned to a first Serving MSC **32**, and enters the area of a base station assigned to a second Serving MSC (not shown in **Figure 1**), the user terminal's registration in the first Serving MSC **32** is cancelled and re-established in the second Serving MSC.

The Gateway MSCs **34** provide similar control functions with respect to user terminals **10, 12** that are camping within the packet switched network **20** or within other networks (not pictured in **Figure 1**). The Gateways MSCs **34** may also perform control functions with respect to the interface **18** between the packet switched network **20** and the circuit switched network **30**. In the case where the networks comprise a GPRS packet switched network **20** and an ANSI 41 circuit switched network **30**, the interface **18** will typically be implemented as a Gs interface **18**. The ANSI 41 circuit switched network may further include an HLR **39**. This HLR may serve as a centralized database for the circuit switched network **30**, where information regarding the various network users is stored and can be accessed by the Gateway MSCs **34** and the Serving MSCs **32**. Control communications between the circuit switched network **30** and the user terminals **10, 12** may be logically transmitted (see previous discussion regarding logical connections provided in the context of the PCCH/PDCH **24**) over a control channel **36**, which in the case of an ANSI 41 circuit switched network, would typically comprise a Digital Control Channel ("DCCH"). Those of skill in the art will recognize in light of the present disclosure, however, that such control communications could also be sent over the Analog Control Channel ("ACC"). Accordingly, it will be recognized that herein any reference to communications sent over the DCCH could alternatively be transmitted over the ACC. Circuit switched communications (*e.g.*, phone calls) between the user terminal **10** and the circuit switched network **30** are carried over a block of communications channels **38**.

As shown in **Figure 1**, the circuit switched network **30** will typically be connected to the Public Switched Telephone Network ("PSTN") **13**. An illustrative device such as a telephone **14** that is hard wire connected to the PSTN **13** is included in **Figure 1**. Additionally, the circuit switched network **30** may further be connected to other circuit switched networks **16** (not pictured in **Figure 1**) and the packet

switched network **20** may be connected to additional packet switched data networks **15** (*e.g.*, the internet). An illustrated device such as a computer **17** that is connected to packet switched data network **15** is included in **Figure 1**.

Mobile user terminals **10** which have dual-mode capabilities (*i.e.*, they support both packet switched and circuit switched communications) may simultaneously be registered in both the packet switched network **20** and the circuit switched network **30**. If the user terminal **10** is actively operating in the circuit switched network **30**, it will typically be registered in that network with one of the Serving MSCs **32**. Under these conditions, circuit switched calls to the user terminal **10** (*e.g.*, a call from user terminal **12** or telephone **14**) are routed to the user terminal **10** by its Serving MSC **32**. When such a circuit switched call is completed, the user terminal **10** will typically camp in the packet switched network **20** and hence will be registered with the Gateway MSC **34** that serves as the Gateway to the packet switched network **20.** When the circuit switched network **30** registers user terminal **10** with the Gateway MSC **34**, the user terminal's registration with the serving MSC **32** is cancelled. Thus, when the user terminal **10** is operating in the packet switched network **20**, the Gateway MSC **34** serves as the control node in the circuit switched network **30** responsible for the user terminal **10**. The Gateway MSC **34** is then able to notify the user terminal **10** to leave the packet switched network **20** when an incoming circuit switched call directed to the user terminal **10** is received over the circuit switched network **30**. Similarly, the user terminal **10** is registered with SGSN control node **22** in the packet switched network **20**. Thus, the SGSN node **22** is responsible for tracking the location of the user terminal **10** when it operates in packet switched mode and is also responsible for routing packet switched communications to and from the user terminal **10.**

Figure 2 is a flow chart illustrating how, in an embodiment of the present invention, a device such as the user terminal **10** can switch from communicating over the packet switched network **20** to the circuit switched network **30**. In the flow chart of **Figure 2**, the user terminal **10** ("User 1") is switching from packet switched service to circuit switched service in response to a call (an "incoming call") placed by another circuit switched user ("User 2"), such as the telephone **14** in **Figure 1**. User 2 places a

call (block **40**) by dialing User 1's telephone number, which results in the incoming call being received at the circuit switched ("CS") network **30** (block **42**). Typically, this incoming call is received in the form of a call origination message, which constitutes a message that in some manner indicates that User 2 is placing a call. Upon receiving the call origination message request from User 2, the circuit switched network **30** sends a page or "notification message" to the packet switched ("PS") network **20** (block **44**) to request notification of User 1 that it is the recipient of an incoming circuit switched call. This page is sent over an interface **18** between the circuit switched network **30** and the packet switched network **20**. (Note that as used herein, the term "interface" refers to a connection between two networks that carries control information and other data between the networks. Typically, the interface is implemented over a hard-wired communications path or over the public switch telephone network **13**. Thus, it will be understood that this network interface does not encompass communications transmission paths which use a cellular user terminal **10** as a relay).

The packet switched network **20** then forwards this page or notification message to User 1 (block **46**). User 1 is notified of the incoming call from User 2 via the packet switched network **20** instead of over a DCCH **36** channel of circuit switched network **30** as User 1 is "camped" in the packet switched network.

As will be understood by those of skill in the art, the "page" or other notification message that is sent from the circuit switched network **30** to the packet switched network **20** (block **44**) may differ in form from the page or other notification message ("the packet switched notification message") that is sent from the packet switched network **20** to User 1 (block **46**). Thus, it will be understood that, as used herein, references to "forwarding" a notification message or a page are intended to encompass any transmission from the packet switched network **20** which instructs User 1 to access the circuit switched network **30** or informs User 1 as to the presence of an incoming circuit switched call, regardless as to the level of similarity between the message sent from the circuit switched network **30** to the packet switched network **20** and the message sent from the packet switched network **20** to mobile user terminal **10**.

As is also shown in **Figure 2**, upon receiving the packet switched notification message, User 1 re-establishes a connection with the circuit switched network **30** (block **48**). This is typically done by User 1 accessing a control channel in the circuit switched network **30**. Thereafter, the circuit switched network **30** sends a suspend message to the packet switched network **20** that instructs the packet switched network that the circuit switched network believes that User 1 had switched from packet switched to circuit switched communications or otherwise provides the packet switched network with information indicating that packet switched service to User 1 should be suspended (block **49**).

The flow chart of **Figure 3** depicts in further detail operations according to an embodiment of the present invention for a user terminal **10** that operates in an ANSI 41 circuit switched network **30** and a GPRS packet switched network **20**. In the flow chart of **Figure 3**, the ANSI 41 network has a single MSC, referred to as a "G/S MSC", which serves as the Serving MSC **32** for network users and which also serves as the Gateway MSC **34**. As will be appreciated by those of skill in the art, ANSI 41 networks may (but do not always) perform the Serving MSC **32** and Gateway MSC **34** functions at different MSC's, and may employ multiple Serving MSCs **32** and/or multiple Gateway MSCs **34**. While **Figure 4** and the associated discussion herein provide more detail regarding implementation of the methods of the present invention in an ANSI 41 network that employs a separate Serving MSC **32** and Gateway MSC **34,** it will be appreciated by those of skill in the art that the systems and methods described and claimed herein may be employed in ANSI 41 circuit switched networks that combine the Serving and Gateway functions in a single MSC, as well as in networks that distribute those functions to multiple MSCs.

As shown in **Figure 3**, the user terminal **10** ("User 1") may decide to switch from packet switched network **20** to circuit switched network **30** because (i) it receives a circuit switched call from another user terminal such as user terminals **12, 14** ("user 2") (block **50**) or (ii) because User 1 decides to place a circuit switched call (block **82**). In the case where User 2 places a call to User 1, operations begin when User 2 dials User 1's number, thereby sending a call origination message to the G/S MSC **32/34** in the circuit switched network **30** (block **52**). Note that more detail

regarding the substeps associated with block **52** are provided in **Figure 5** herein and the text associated therewith. Upon receiving the call origination message (block **54**), the G/S MSC **32/34** determines if User 1 is currently camped on the ANSI 41 circuit switched network **30** or in the GPRS packet switched network **20** (block **56**). If User 1 is camped in the ANSI 41 network, the G/S MSC **32/34** may send a page directly to User 1 over the ANSI 41 DCCH control channel **36** (block **58**). User 1, which is connected to the DCCH **36**, then receives the page (block **60**). In response to the page, User 1 transmits a "page response" message back to the G/S MSC **32/34** over the DCCH (block **62**), at which point the G/S MSC **32/34** may establish a call connection (*i.e.,* provides the transmission path for the circuit switched call between User 1 and User 2) (block **64**). In the event that User 1 is currently on another call at the time it receives the time the call origination message is received from User 2 at the G/S MSC **32/34**, the G/S MSC **32/34** will send a message back to User 2 that results in User 2 receiving a busy signal in response to its call origination request.

If, however, the G/S MSC **32/34** determines (block **56**) that User 1 is currently camped on the GPRS network **20**, then User 1 is notified to re-establish its connection to the ANSI 41 network **30**. The G/S MSC **32/34** may accomplish this by sending a page or notification message to the SGSN control node **22** in the packet switched GPRS network **20** (block **66**). Preferably, this is accomplished by sending the page across the Gs interface **18**. Upon receiving this notification message from the ANSI 41 circuit switched network **30**, the SGSN node **22** transmits a packet switched notification message (which might be implemented as a network page) to User 1, typically via either the PCCH or the PDCH packet control channels **24** (block **68**).

Upon receiving the packet switched notification message (block **70**), User 1 may immediately suspend communications in the packet switched network **20** without informing the SGSN control node **22** that it is disconnecting from the GPRS network **20** (block **72**). Upon suspending communications in the packet switched network **20**, User 1 accesses the DCCH control channel **36** in the ANSI 41 circuit switched network **30** (block **72**). Once that access is achieved, User 1 sends a page response message to the G/S MSC **32/34** via the DCCH **36** (block **74**). Upon receiving this message, the G/S MSC **32/34** realizes that User 1 has re-established its connection

with the ANSI 41 circuit switched network **30** and connects the call between User 2 and User 1 (block **76**).

While, at this point, the User 2 to User 1 call has been connected, the GPRS network **20** still may not realize that User 1 has suspended its communications in the packet switched network **20**. Accordingly, the G/S MSC **32/34** sends a notification to the SGSN control node **22** advising the GPRS packet switched network **20** that User 1 has suspended its communications in the packet switched network **20** and that accordingly, all packet switched communications to User 1 should be suspended (block **78**). The G/S MSC **32/34** may advantageously accomplish this without any additional message from User 1, and the "suspend" message may advantageously be sent over the Gs interface **18**, which is typically a hard wire that is not capacity limited as opposed to sending a message to the SGSN node **22** over (typically) capacity limited wireless links **26** (see **Figure 1**). Upon receipt of the suspend message, the SGSN node **22** may need to determine if the suspend message is valid (i.e., if it indicates that a user terminal 10 has exited packet switched service and connected to circuit switched service) (block **79**). Such a step may be required because the ANSI 41 network may be configured to automatically send a suspend message anytime the registration of a user terminal **10** in a Gateway MSC **34** is cancelled. In such a network implementation, false suspend messages may be forwarded to the SGSN node **22** (*e.g.*, when a mobile user terminal **10** moves from an area serviced by one Gateway MSC **34** to the area serviced by another Gateway MSC **34**). The SGSN node **22** may determine whether suspension of packet switched communications is warranted in a variety of ways, including by reviewing control information (such as which Gateway MSC **34** sent the suspend message) regarding the ANSI 41 network **30** forwarded over the Gs interface **18**. If the SGSN node **22** determines that the suspend message is valid (*i.e.*, that service should be suspended), it suspends packet switched service to User 1 pending User 1's re-registration with the GPRS packet switched network **20** (block **80**).

Figure 3 also illustrates a method by which User 1 could switch from packet switched service to circuit switched service in the event that User 1 decides to place a circuit switched call (block **82**). As shown in **Figure 3**, if User 1 is already operating

or camped on the ANSI 41 network **30** (decision block **84**), all User 1 need do is send a call origination message over the DCCH **36** to the G/S MSC **32/34** (block **62**), and the call may then be connected (block **64**). If, instead (block **84**), User 1 is camped on the GPRS network **20**, User 1 must first exit packet service and access the ANSI 41 network DCCH **36** (block **72**) and operations proceed as described previously for blocks **72, 74, 76, 78**, and **80**.

Note that in block **74** of **Figure 3**, User 1 sends either a call origination message or a page response (*i.e.*, a response to the notification message notifying User 1 of the incoming call from User 2) to the G/S MSC **32/34**. Herein, the term "call connection message" is used to refer to such a message from User 1 to the circuit switched network **30** where the message can be either a call origination message or a page response.

As noted above, in at least some ANSI 41 networks **30**, the Serving MSC **32** and the Gateway MSC **34** are implemented at different nodes. The flow chart of **Figure 4** illustrates a representative method of requesting suspension of packet switched service to User 1 and switching User 1 from the packet switched network **20** to the circuit switched network **30** when User 1 desires to place or receive a circuit switched call in such an environment. As with **Figure 3**, the flow chart of **Figure 4** assumes that User 1 operates in a GPRS packet switched network **20** and in an ANSI 41 circuit switched network **30**. However, this particular embodiment is depicted only to ensure that the present disclosure fully explains how the methods of the present invention could be implemented in a representative network, and it will be understood that the present invention is not limited to GPRS and ANSI 41 network implementations.

As shown in **Figure 4**, one reason that the user terminal **10** ("User 1) may wish to suspend packet switched communications is because it receives an incoming call. As in the example of **Figure 3**, this occurs, for example, when another device ("User 2") decides to call User 1 (block **90**) and then places a call which results in a call origination message being delivered to the ANSI 41 network **30** (block **92**). A control device or node in the ANSI 41 network **30** (typically a Serving MSC **32** which obtains data from the ANSI 41 network HLR **39**) then determines whether User 1 is

currently operating in the ANSI 41 network **30**, as opposed to, for example, camping on the GPRS network **20** (block **94**). If User 1 is currently registered in the ANSI 41 network **30**, the call origination message resulting from User 2's placement of the call is delivered to the Serving MSC **32** that is assigned to User 1 (block **96**). This Serving MSC **32** then sends a page or message to User 1 via the DCCH **36** notifying User 1 of the call (block **98**). After User 1 receives the page (block **100**), User 1 transmits a page response back to the Serving MSC (block **102**), acknowledging the page. The Serving MSC **32** then establishes the connection between User 1 and User 2 thereby connecting the call (block **104**).

If, instead, at block **94** the Serving MSC **32** determines that User 1 is currently operating in the GPRS network **20**, the call origination message is delivered to the Gateway MSC **34** assigned to User 1 (block **106**). This Gateway MSC **34** then send a page or notification message to the SGSN control node **22** in the GPRS packet switched network **20**, via the Gs interface **18**, which contains information informing User 1 of the incoming call and/or instructing User 1 to access the ANSI 41 network **30** (block **108**). The SGSN control node **22** then forwards this page (or notification message) information to User 1, typically via the PCCH or PDCH **24** (block **110**).

The message from the Gateway MSC **34** to User 1 that is transmitted via the SGSN control node **22** may be forwarded in a variety of ways. In one such way, it is "tunneled" through the SGSN **22** to User 1. This means that the SGSN **22** is unaware of the actual contents of the message being sent to User 1, but instead is only aware that it needs to forward an underlying message to User 1. By the use of tunneling, greater autonomy is possible between the ANSI 41 network **30** and the GPRS network **20**, which can advantageously simplify the control of the combined system. As noted above, it will also be understood by those of skill in the art that a variety of different messages (packet switched notification messages) may be sent from the Gateway MSC **34** to User 1 via the SGSN **22** to notify User 1 of an incoming call.

Once User 1 receives the page or message which was sent in response to the call origination from User 2 (block **112**), User 1 leaves the GPRS network **20** and accesses the DCCH **36** in the ANSI 41 network (block **114**). As User 1 is receiving a call (block **116**) it then sends a page response over the DCCH **36** to its Serving MSC

32 (block 118). As User 1 at this point, however, is still registered with the Gateway MSC 34, the Serving MSC 32 typically will not be anticipating a page response. Accordingly, as the page response from User 1 was unsolicited, Serving MSC 32 sends out an unsolicited response (UNSOLRES) message to all Gateway MSCs 34 (block 120), as the unsolicited response presumably is a response to a page that was sent by a Gateway MSC 34 to a user who was not operating in the ANSI 41 network 30. This message provides notification to the Gateway MSC 34 that the user terminal 10 has accessed the ANSI 41 network.

As shown in **Figure 4**, once the Gateway MSC 34 that was previously assigned to User 1 receives the unsolicited response message, it may send a suspend message to the SGSN node 22 in the GPRS packet switched network 20 via the Gs interface 18 (block 122). The Gateway MSC 34 does this based on its knowledge that the user terminal 10 is currently registered in it (because it was operating in the GPRS network 20), yet is sending a message to the Serving MSC 32 with which the user terminal 10 is not registered. Thus, based on the registration status of user terminal 10, Gateway MSC 34 determines that the user terminal 10 has switched from the GPRS network 20 to the circuit switched network 30.

Note that in the blocks 120, 122, 124 connection, the suspend message is generated by the ANSI 41 network 30 as opposed to the user terminal 10, and that it is delivered via an inter-network control interface 18 as opposed to via (typically) capacity limited wireless transmission link (not shown). This approach is preferred over the alternative approach depicted in blocks 128, 130, 122 of **Figure 4** (where the suspend message is sent after the HLR 39 cancels User 1's registration in the Gateway MSC 34), as it expedites delivery of the suspend message to the GPRS network 20, and, thus, may minimize the amount of packet data traffic that will be sent to User 1 after User 1 has left the GPRS network 20. In any event, after (or, alternatively, before) the Serving MSC 32 sends out the unsolicited response message, the Serving MSC 32 and Gateway MSC 34 establish the connection between User 1 and User 2 (block 126). At this point (or before establishing the call), the Serving MSC 32 registers User 1 with the ANSI 41 HLR 39 (block 128). The HLR 39 then cancels User 1's registration with the Gateway MSC 34 (block 130). Finally, after the

Gateway MSC **34** sends the suspend message to the SGSN control node **22** in the GPRS network **20** (block **122**), the GPRS network **20** suspends packet service to User 1 (block **124**).

Figure 4 also illustrates operations by which User 1 may switch from packet switched communications to circuit switched communications in the event that User 1 decides to place a circuit switched call (block **132**). As shown in **Figure 4**, if User 1 is already camped or operating in the ANSI 41 network, all User 1 need do is send a call origination message over the DCCH **36** to the Serving MSC **32** (block **102**), and the call may then be established (block **104**). (Note, that for purposes of simplifying the flow chart a decision block such as the decision block **84** included in **Figure 3** was not also included in Figure 4, but is obviously present). If, instead, User 1 is camped in the GPRS network **20**, User 1 must first exit packet service and access the ANSI 41 network DCCH **36** (block **114**). As User 1 is originating the call (block **116**), the call origination message may then be sent to the Serving MSC **32** via the DCCH **36** (block **134**), and the call is thereafter connected (block **136**). Thereafter, blocks **128, 130, 122** and **124** proceed as described previously. Also note that, as in the case of **Figure 3**, the additional step of having the SGSN control node **22** determine if the suspend message is valid may be included in the method depicting in **Figure 4**. Such a determination would occur between blocks **122** and **124** in **Figure 4**.

As illustrated in both **Figure 3** and **Figure 4**, operations according to various embodiments of the present invention may be initiated after a user terminal ("User 2") decides to place a call to mobile user terminal **10** ("User 1"). **Figure 5** is a flow chart depicting additional details of one possible method of notifying the Serving MSC **32** to which User 1 will be assigned upon returning to the ANSI 41 network **30** of the call from User 2 (corresponding to blocks **52** and **54** in **Figure 3** and to blocks **92, 94, 96** and **106** in **Figure 4**). As shown in **Figure 5**, after User 2 decides to send a call to User 1 (block **140**), User 2 dials User 1's number which results in a call origination message being sent to a control node responsible for User 2 such as a Serving MSC **32** (if User 2 is in the ANSI 41 network **30**) or a local exchange (if User 2 is in the public telephone network **13**) (block **142**). The control node receiving the call origination message then sends the call origination message to the "Home MSC"

assigned to User 1 (block **144**), where the term "Home MSC" refer to the MSC assigned to receive call origination messages directed to User 1.

As the Home MSC typically will not track the location of User 1 when it is operating in the packet switched network **20**, upon receiving this call origination message, the Home MSC sends a routing request to the ANSI 41 HLR **39** (block **146**). In response to this routing request, the ANSI 41 HLR **39** sends a request for a telephone location directory number ("TLDN") to the MSC where User 1 is registered (block **148**). The MSC with which User 1 is currently registered (which will be a Gateway MSC **34** if User 1 is camped in the GPRS network **30** or a Serving MSC **32** if User 1 is registered in the ANSI 41 network **30**) sends a TLDN to the HLR **39** informing the HLR **39** as to the location of User 1 (block **150**). The HLR **39** then sends the TLDN to the Home MSC for User 1 (block **152**). The Home MSC then routes the call origination message from User 2 to User 1's MSC (which, if User 1 is camped in the GPRS network **20**, is a Gateway MSC **34**) (block **154**).

While the systems and methods of the present invention are particularly useful in mobile cellular telephone applications, it will be understood by those of skill in the art that various of the methods and systems described herein may be used in other applications. Thus, while in a preferred embodiment of the present invention, the methods are employed in ClassB136 Mobile systems which include user terminals operating in both an ANSI 41 circuit switched network **30** and in a GRRS packet switched network **20**, it will be appreciated that the present invention may be used in other dual-mode systems.

It will be appreciated by those of skill in the art in light of the teachings of the present disclosure that the methods and systems of the present invention may reduce the time it takes for a user terminal **10** to switch from packet switched service to circuit switched service. Pursuant to the prior method specified for dual mode user terminals **10** operating in an ANSI 41 network **30** and a GPRS network **20**, the switchover could not typically occur until a message to suspend packet switched communications was sent by the user terminal **10** to the GPRS network **20**. This message was generally transmitted using a contention based access mode on the packet switched communications channels **26**, and, hence, could be subject to

considerable delay if the packet switched communications channels **26** were being heavily used by others. Thus, the use of an air interface for transmission of the suspend notification could result in an extra delay in the paging process.

In typical network implementations, the time required to send a suspend message over the contention based access to the packet switched network **20** is about one second. The other significant delays in the above-mentioned prior switch over method may include (i) the time required to send the call origination message to the Gateway MSC **34**, (ii) the time it takes the user terminal **10** to access the DCCH **36** (approximately one second), and (iii) the time required to send the page from the SGSN control node **22** to the user terminal **10** (approximately 1 second on average). Thus, the methods and systems of the present invention may reduce the time required to switch over to the circuit switched network **30** from X+3 seconds to X+2 seconds, where X is the time required to send the call origination message to the Gateway MSC **34**. When the switchover is made because User 1 desires to originate a call, the switchover time is reduced from X+2 seconds to X+1 seconds.

Pursuant to another aspect of the present invention, the Serving MSC **32** and/or the Gateway MSC **34** may send a message to the SGSN control node **22** indicating that packet switched communications to user terminal **10** should be resumed. This message may be sent whenever a suspend notice was previously sent and the dialogue which initiated that suspend message has terminated. Once packet switched service has successfully been resumed, the user terminal **10** may be informed of the resumption either in the release message (if the ANSI 41 network base station initiates the release) or in the acknowledgement message from the base station **33, 35, 37** (if the user terminal **10** initiates the release).

Figures 6 through **9** schematically depict the sequences of messages between various network resources which may be used to accomplish a switchover from packet switched service to circuit switched service pursuant to various embodiments of the present invention. **Figure 6** illustrates a sequence of messages which may be used to perform a switchover in response to an incoming call to the user terminal **10** when the Serving MSC **32** and the Gateway MSC **34** are implemented in the same device. As shown in **Figure 6**, initially the user terminal **10** is camped in the GPRS

packet switched network **20**, where it is connected to a base station **27** via PCCH/PDCH **24** (arrow **160**). After G/S MSC **32/34** is notified of the incoming call to user terminal **10**, it sends a page to the SGSN **22** via Gs interface **18** (arrow **162**). This page results in a paging request being sent by the SGSN **22** to the base station **27** (arrow **164**), from which it is forwarded to the user terminal **10** (arrow **166**). Upon receiving the paging request, the user terminal **10** re-establishes its connection to the ANSI 41 network **30** DCCH **36** (arrow **168**), and sends a page response to the G/S MSC **34** over the DCCH **36** (arrow **170**). The G/S MSC **32/34** then sends an instruction to suspend packet service to the SGSN control node **22** via the Gs interface **18** (arrow **172**), which is thereafter acknowledged by the SGSN **22** (arrow **174**). Thereafter, the G/S MSC **32/34** may request the service profile of the user terminal **10** via a QUALREQ message that is sent to the HLR **39** (arrow **176**), and the HLR **39** provides this information via a qualreq message (arrow **178**). A Digital Traffic Channel ("DTC") is then assigned to the user terminal **10** by the G/S MSC **32/34** (arrow **184**) and the user terminal **10** is alerted regarding this assignment (arrow **186**). Finally, the user terminal **10** is connected to the incoming call (arrow **188**).

Figure 7 also depicts the switchover procedure in response to an incoming call except, in this example, the Gateway MSC **34** is not the Serving MSC **32**. In **Figure 7**, the switchover sequence is identical to that described above with respect to **Figure 6** up to the point where the user terminal **10** transmits the page response (arrow **200**), except that the Gateway MSC **34**, instead of a combined G/S MSC **32/34**, sends the page to the SGSN **22** (arrow **192**). As shown in **Figure 7**, the response from user terminal **10** to this page (arrow **200**) is sent to the Serving MSC **32**, and, thereafter, the Serving MSC **32** and the HLR **39** exchanges QUALREQ and qualreq messages (arrows **202** and **204**) as discussed previously with respect to arrows **176, 178, 184** in **Figure 6**. A DTC is then assigned to the user terminal 10 by the Serving MSC 32 (arrow **206**). The Serving MSC **32** also sends out a UNSOLRES message to all the Gateway MSCs **34** (arrow **208**), and the user terminal **10**'s former Gateway MSC **34** thereafter send an instruction to suspend packet switched communications to the user terminal **10** to SGSN **22** (arrow **210**), which is thereafter acknowledged by the SGSN (arrow **212**). The Gateway MSC **34** then sends a ISSETUP message to the Serving

MSC **32** (arrow **220**) which requests that the Serving MSC **32** perform call setup actions. The Serving MSC **32** replies with an issetup message when the actions are completed (arrow **222**) and the Gateway MSC **34** sets up the call connection (arrow **224**). Finally, the Serving MSC **32** alerts the user terminal **10** that the call connection has been established (arrow **226**).

Figures 8 and **9** depict a switchover sequence which may be followed when user terminal **10** decides to originate a circuit switched call when camped in the packet switched network **20** (arrow **230**). When the ANSI 41 network **30** has a combined G/S MSC **32/34** (**Figure 8**), the user terminal **10** may simply access the DCCH **36** (arrow **232**) and send the call origination to the G/S MSC **32/34** (arrow **234**). The G/S MSC **32/34** then notifies the SGSN **22** to suspend packet service (arrow **236**), and may receive an acknowledgment of such a suspension from the SGSN **22** (arrow **238**). Thereafter, the DTC is assigned and the call is connected (arrows **240, 242**).

As shown in **Figure 9**, when the Serving and Gateway MSC functions are not combined, the first two events (arrows **250** and **252**) are identical to arrows **230** and **232** in **Figure 8**. Thereafter, however, the call origination message from the user terminal **10** is sent to the Serving MSC **32** (arrow **254**). The Serving MSC **32** may then obtain the service profile of the user terminal **10** from the HLR **39** by sending it a QUALREQ message (arrow **256**), and that information is provided in the qualreq response (arrow **258**). A DTC is then assigned to the call by the Serving MSC **32**. Thereafter, the Serving MSC **32** will notify the HLR **39** of the new location of the user terminal **10** in a REGNOT message (arrow **268**), and the HLR **39** will cancel the registration of user terminal **10** in the Gateway MSC **34** in a REGCANC message (arrow **270**). At this point, the Gateway MSC **34** will send a suspend message to the SGSN **22** which will be acknowledged in a return message from the SGSN **22** (arrows **272, 274**). The Gateway MSC **34** will then acknowledge the registration cancellation to the HLR **39** (arrow **276**), and the HLR **39** acknowledges the registration of the user terminal **10** in the Serving MSC **32** in a regnot message (arrow **278**).

The present invention has been described herein with respect to various flowcharts. It will be understood that each block of the flowchart illustrations, and

combinations of blocks in the flowchart illustrations, can be implemented in software. Thus, while the present invention has been primarily described in terms of methods, those of skill in the art will appreciate that systems, which will often comprise software, can be established to implement these methods. Such software would include computer program instructions which may be provided to a processor to produce a machine, such that the instructions which execute on the processor create means for implementing the functions specified in the flowchart block or blocks. The computer program instructions may be executed by a processor to cause a series of operational steps to be performed by the processor to produce a computer implemented process such that the instructions which execute on the processor provide steps for implementing the functions specified in the flowchart block or blocks.

Accordingly, blocks of the flowchart illustrations provided herein support combinations of means for performing the specified functions, combinations of steps for performing the specified functions and program instruction means for performing the specified functions. It will also be understood that each block of the flowchart illustrations, and combinations of blocks in the flowchart illustrations, can be implemented by special purpose hardware-based systems which perform the specified functions or steps, or combinations of special purpose hardware and computer instructions. It will also be appreciated that the means for performing the specified functions may be located at any of a variety of network resources, and further that in many cases it will be most efficient to distribute the logic that forms the system at a number of nodes in the packet switched and circuit switched networks.

In the drawings, specification and examples, there have been disclosed typical preferred embodiments of the invention and, although specific terms are employed, these terms are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being set forth in the following claims.

THAT WHICH IS CLAIMED IS:

1. A method of requesting suspension of packet switched communications to a user terminal that is configured to operate in both a circuit switched network and a packet switched network, the method comprising the steps performed by the circuit switched network of:

receiving a call connection message from the user terminal;

determining based on a registration status of the user terminal if the user terminal has switched from the packet switched network to the circuit switched network responsive to the received call connection message; and

sending a suspend message from the circuit switched network to the packet switched network via an interface between the circuit switched network and the packet switched network if the user terminal has switched from the packet switched network to the circuit switched network.

2. The method of Claim 1, wherein the sending a suspend message step is followed by the step of establishing a call connection for the user terminal.

3. The method of Claim 1, wherein the circuit switched network is an ANSI 41 network having a Serving MSC and a Gateway MSC and the packet switched network is a GPRS network having a SGSN node;

wherein said receiving step comprises the step of receiving at the Serving MSC a call connection message from the user terminal; and

wherein said sending step comprises the step of sending a suspend message from the Gateway MSC to the SGSN node via an interface between the ANSI 41 network and the GPRS network.

4. The method of Claim 3, wherein said determining step comprises the step of:

providing notification to the Gateway MSC that the user terminal has accessed the ANSI 41 network; and

determining at the Gateway MSC based on the notification and the registration status of the user terminal that the user terminal has switched from the packet switched network to the circuit switched network.

5. The method of Claim 4, wherein said providing notification step comprises the step of sending an unsolicited response message from the Serving MSC to the Gateway MSC in response to receiving the call connection message.

6. The method of Claim 4, wherein said providing notification step comprises the steps of:

registering the user terminal with the Serving MSC; and

sending a registration cancellation message to the Gateway MSC.

7. The method of Claim 1, wherein said receiving step comprises the step of receiving a call origination message from the user terminal.

8. The method of Claim 1, wherein said receiving step is preceded by the steps performed by the circuit switched network of:

receiving an incoming call to the user terminal at the circuit switched network;

transmitting a notification message from the circuit switched network to the packet switched network via the interface between the circuit switched network and the packet switched network notifying the user terminal to access the circuit switched network; and

wherein said receiving step comprises the step of receiving a response to the notification message from the user terminal; and

further comprising the step performed by the packet switched network of forwarding the notification message from the packet switched network to the user terminal.

9. The method of Claim 8, wherein the step of transmitting a notification message comprises the step of transmitting a notification message from the Gateway MSC to the SGSN via a Gs interface; and

wherein the step of forwarding the notification message comprises the step of transmitting a packet switched notification message from the SGSN to the user terminal.

10. The method of Claim 9, wherein the step of transmitting a packet switched notification message from the SGSN to the user terminal comprises the step of tunneling the notification message sent by the Gateway MSC to the user terminal in the packet switched notification message transmitted by the SGSN.

11. A method of switching a user terminal that is configured to operate in both an ANSI 41 circuit switched network having a Serving MSC and a Gateway MSC and a GPRS packet switched network having a SGSN node from GPRS communications to ANSI 41 communications, the method comprising the steps of:

accessing at the user terminal a control channel in the ANSI 41 network;

sending a message from the user terminal to the Serving MSC;

providing notification to the Gateway MSC that the user terminal has accessed the ANSI 41 network;

sending a suspend message from the Gateway MSC to the GPRS network via an interface between the GPRS network and the ANSI 41 network responsive to receiving said notification at the Gateway MSC;

suspending packet switched communications between the GPRS network and the user terminal responsive to receiving the suspend message from the ANSI 41 network; and

allocating an ANSI 41 communications channel to the user terminal.

12. The method of Claim 11, wherein said step of providing notification to the Gateway MSC comprises the step of sending an unsolicited response message

from the Serving MSC to the Gateway MSC in response to the user terminal sending the message to the Serving MSC.

13. The method of Claim 12, wherein said step of providing notification to the Gateway MSC comprises the steps of:

registering the user terminal with the Serving MSC; and

canceling a registration of the user terminal in the Gateway MSC.

14. The method of Claim 11, wherein said accessing step is preceded by the step of the user terminal deciding to originate a call in the ANSI 41 network; and

wherein the message sent from the user terminal to the Serving MSC comprises a call origination message.

15. The method of Claim 11, wherein said accessing step is preceded by the steps of:

receiving an incoming call to the user terminal at the ANSI 41 network;

notifying the user terminal of the incoming call; and

wherein the message sent from the user terminal to the Serving MSC comprises a page response.

16. The method of Claim 15, wherein the step of notifying the user terminal of the incoming call comprises the steps of:

transmitting a notification message from the Gateway MSC to the SGSN via the interface between the GPRS network and the ANSI 41 network; and

transmitting a packet switched notification message from the SGSN to the user terminal.

17. The method of Claim 16, wherein the step of transmitting a packet switched notification message from the SGSN to the user terminal comprises the step of tunneling the notification message sent by the Gateway MSC to the user terminal in the packet switched notification message transmitted by the SGSN.

18. The method of Claim 12, further comprising the step of determining at the GPRS network whether the suspend message indicates that the user terminal has accessed the ANSI 41 network; and

wherein said suspending step comprises the step of suspending packet switched communications between the GPRS network and the user terminal responsive to receiving the suspend message from the Gateway MSC in the event the GPRS network determines in said determining step that the user terminal has accessed the ANSI 41 network.

19. A system for requesting suspension of packet switched communications to a user terminal that is configured to operate in both a circuit switched network and a packet switched network, the system comprising:

means for receiving a call connection message from the user terminal;

means for determining based on a registration status of the user terminal if the user terminal has switched from the packet switched network to the circuit switched network; and

means for sending a suspend message from the circuit switched network to the packet switched network via an interface between the circuit switched network and the packet switched network if the user terminal has switched from the packet switched network to the circuit switched network.

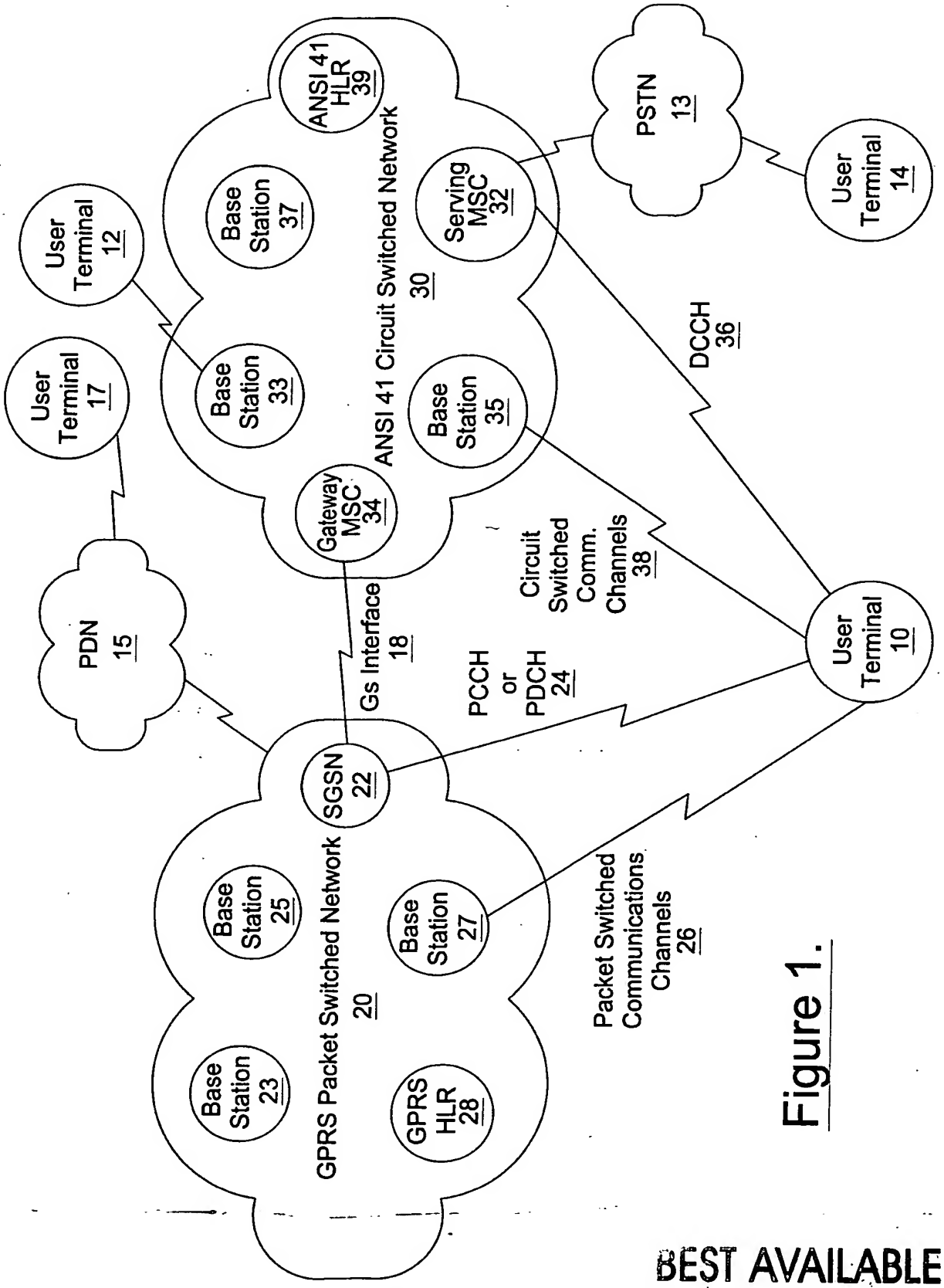


Figure 1.

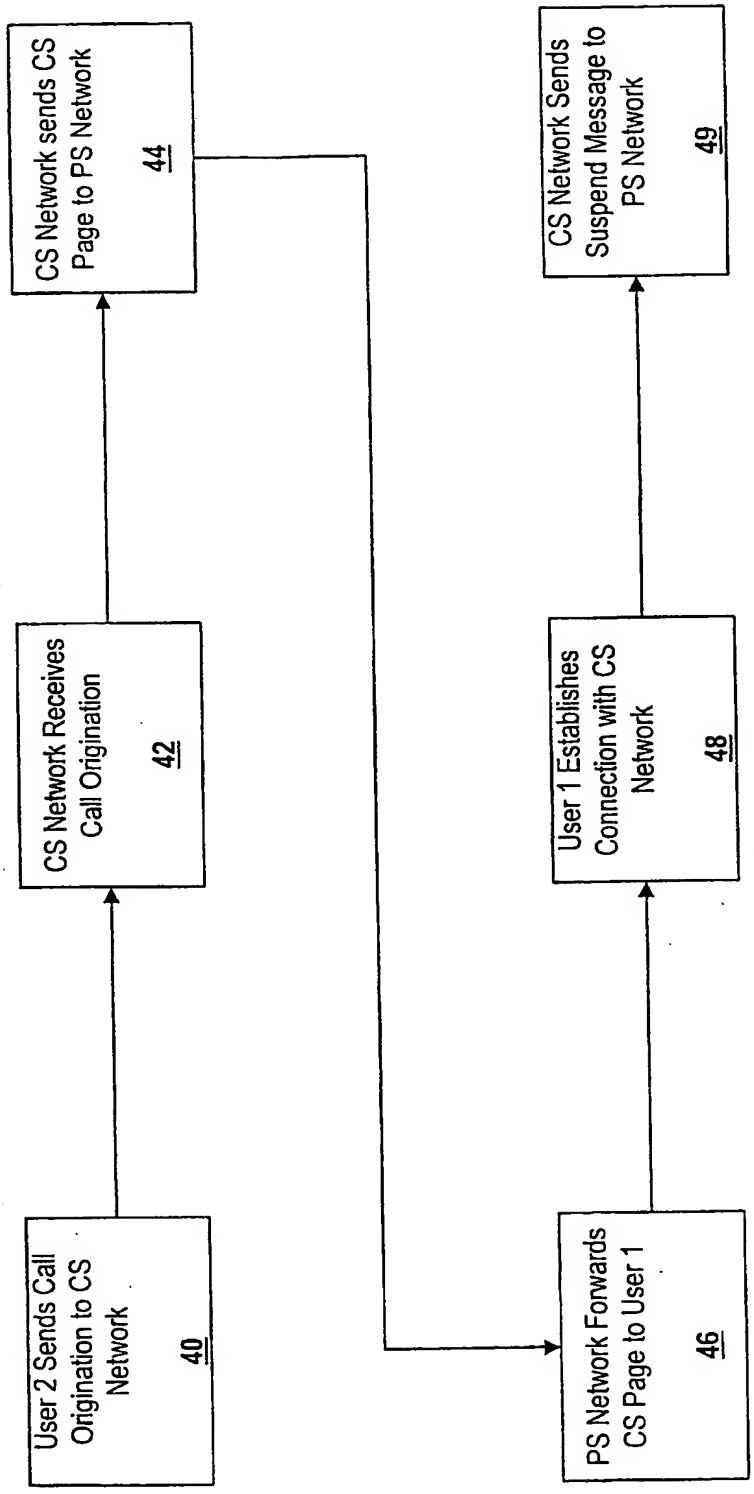
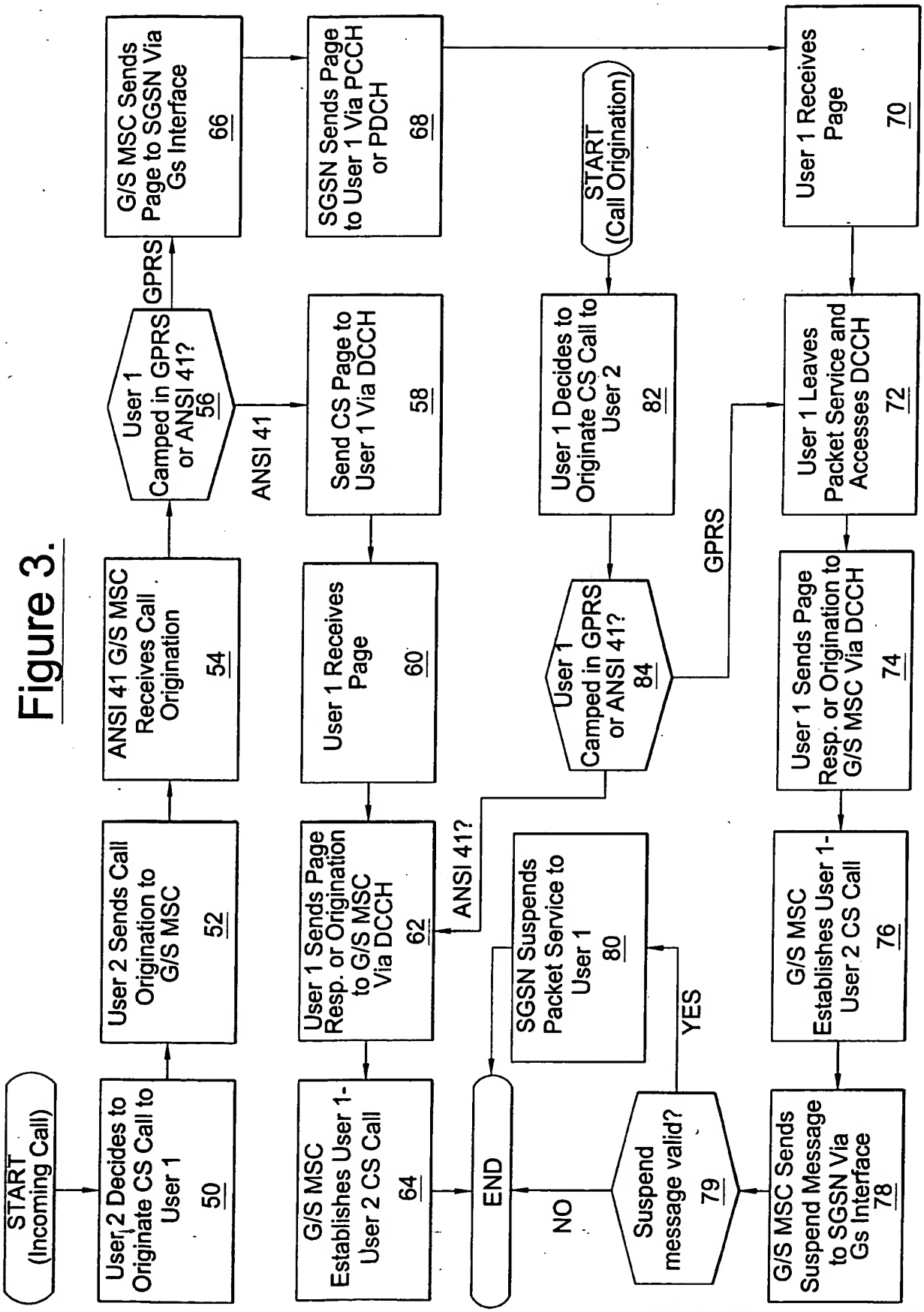


Figure 2

Figure 3.



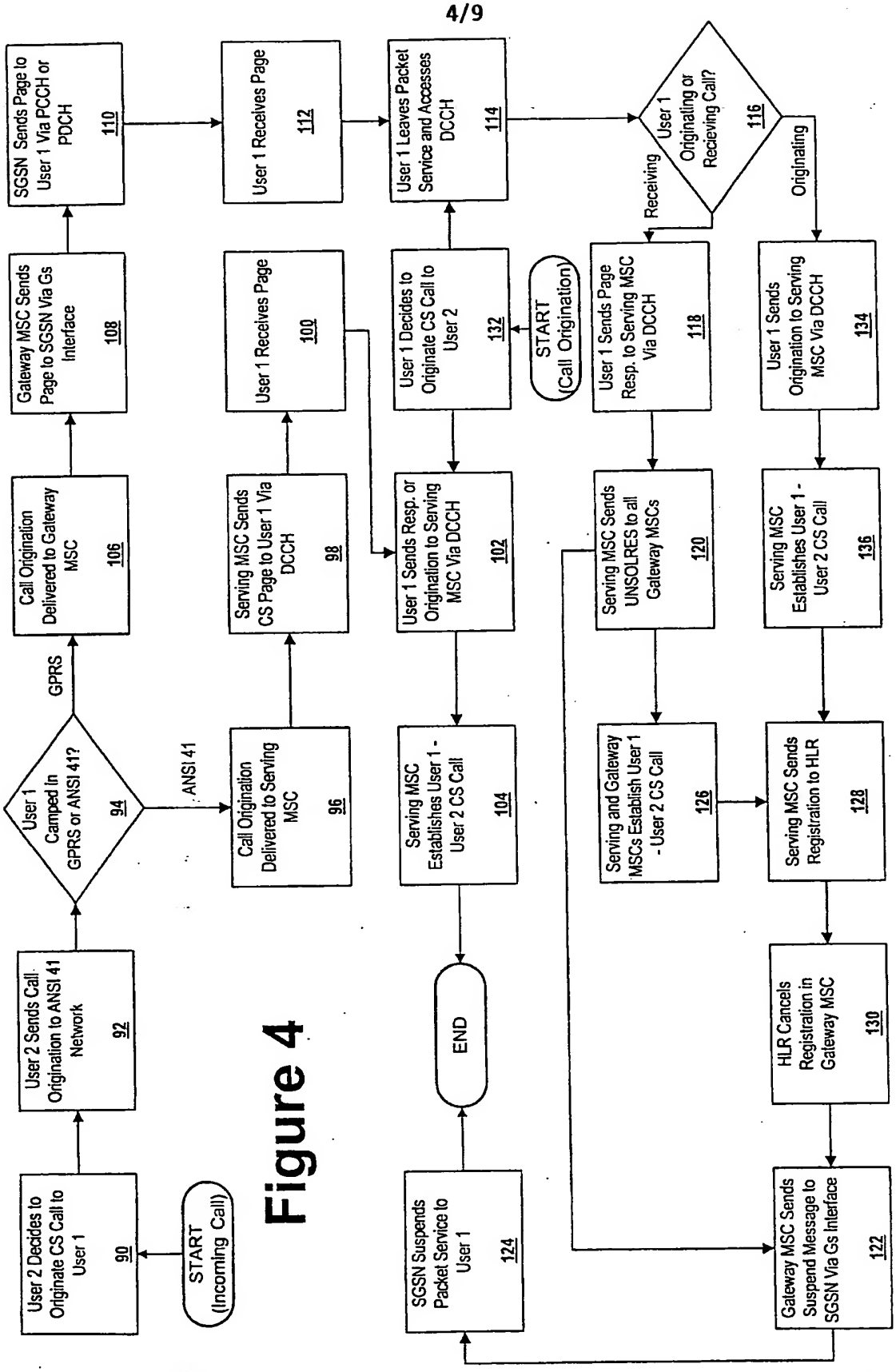


Figure 4

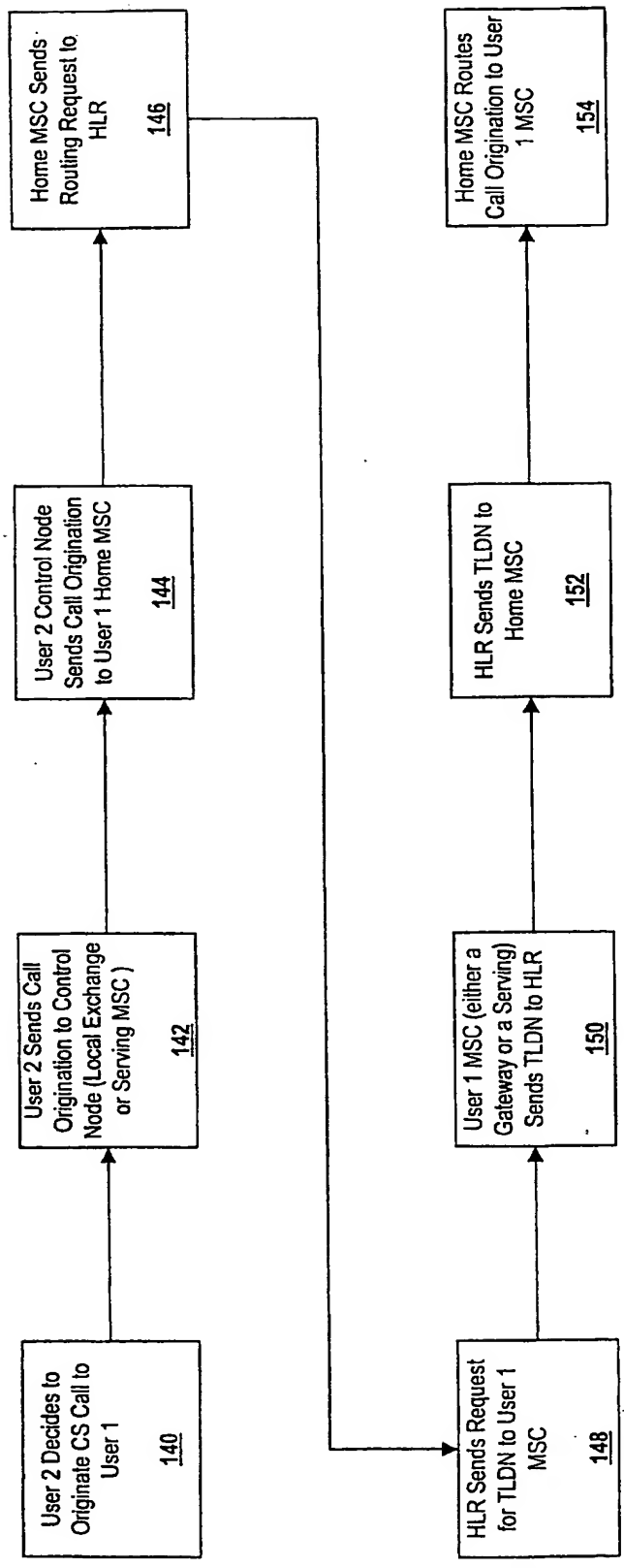
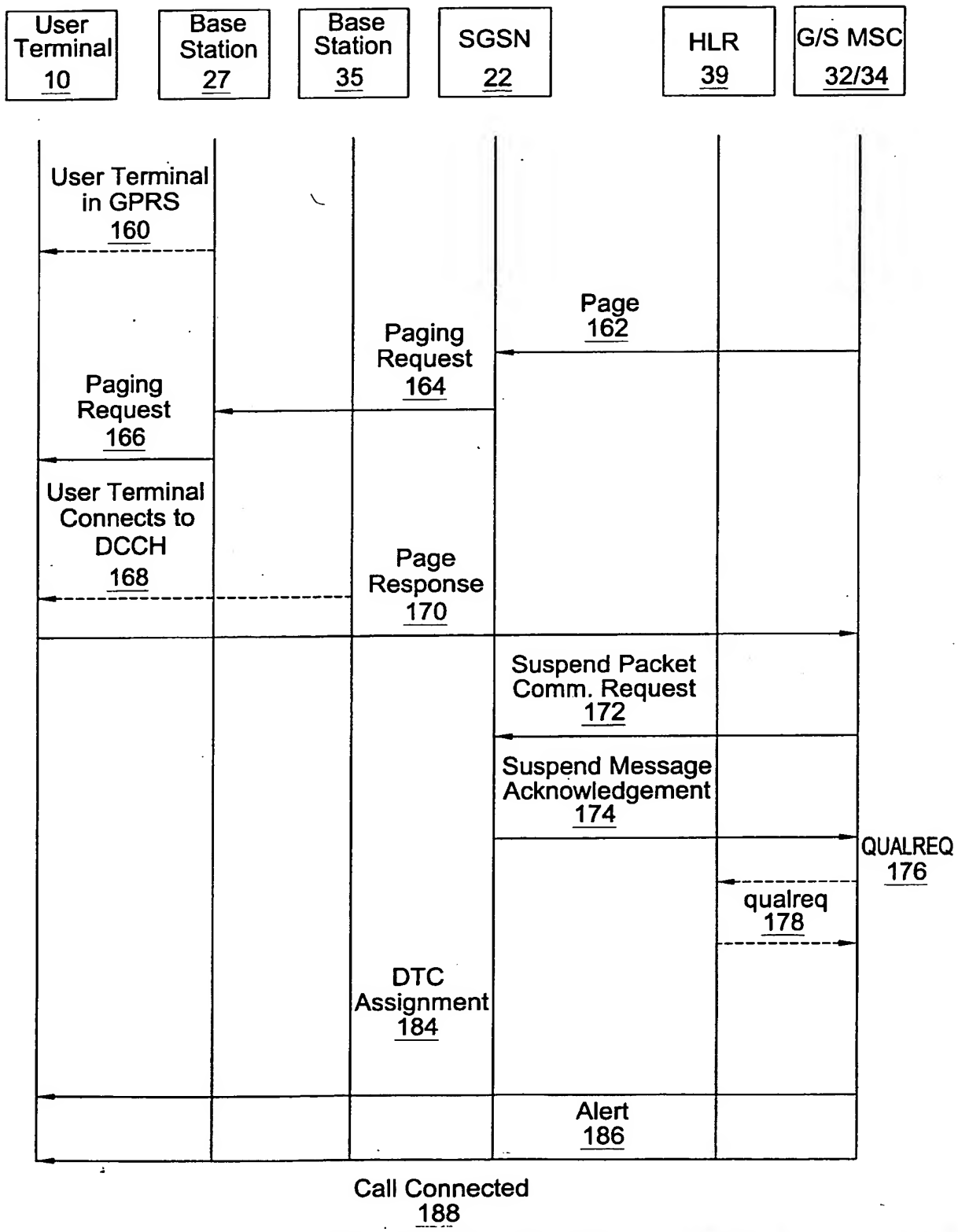


Figure 5

Figure 6.



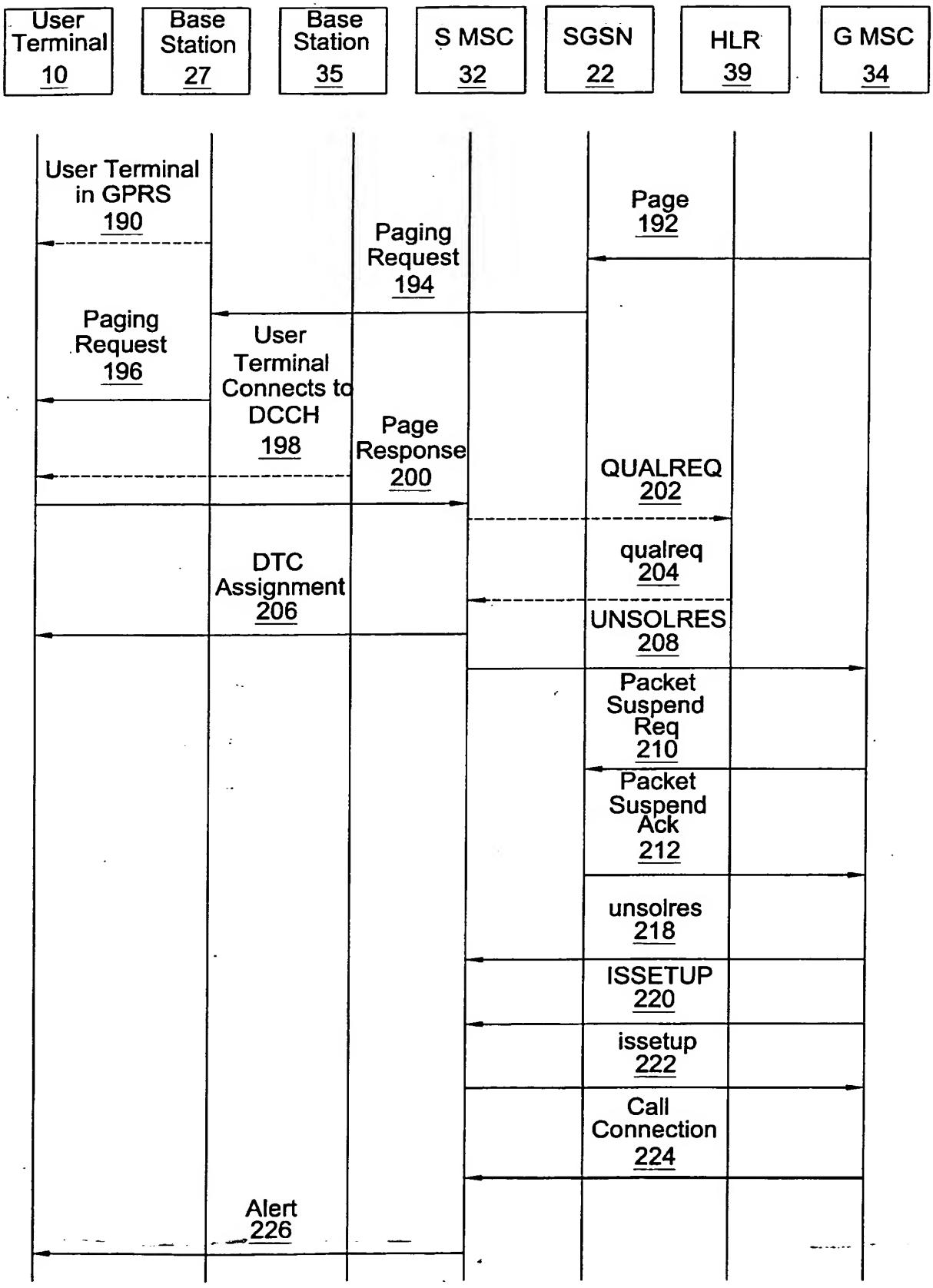


Figure 7.

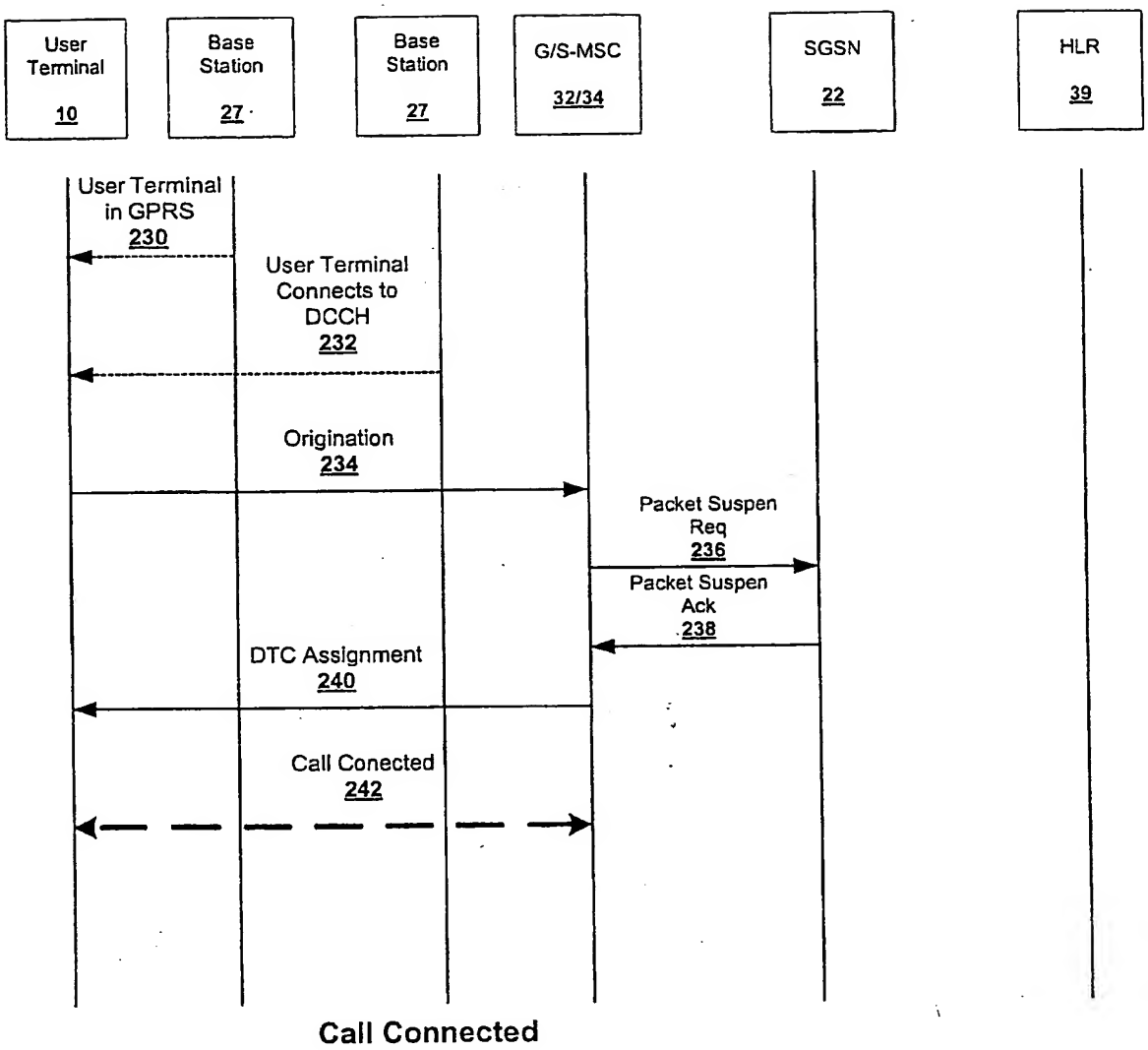


Figure 8

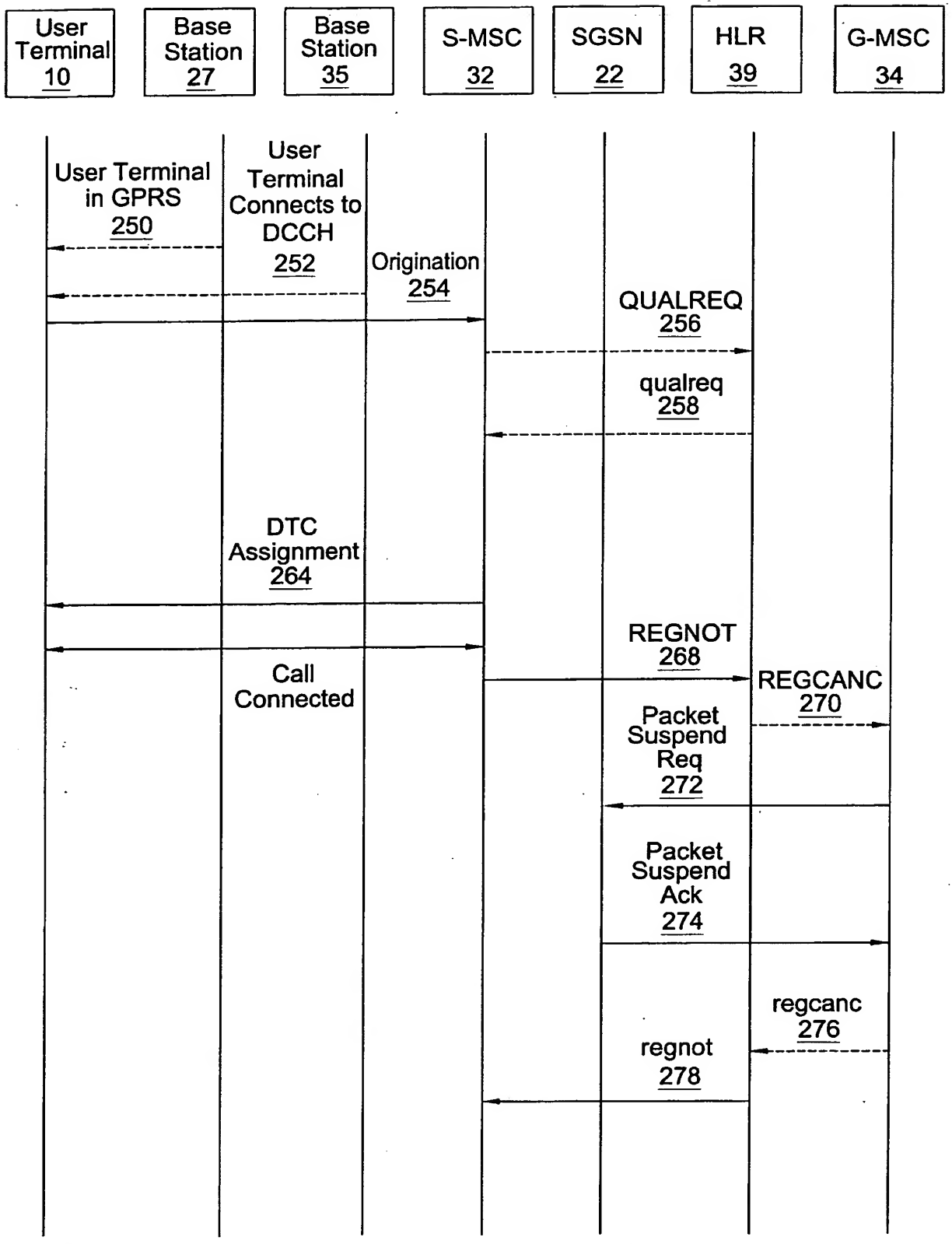


Figure 9.